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ASTM F2376-2006: Standard Practice for Design of Amusement Rides and Devices as required by: Commonwealth of Virginia, 13 VAC 5-31-40(A)(2)

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Designation: F 2376 – 06

Standard Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems[1]

This standard is issued under the fixed designation F 2376; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice applies to the classification, design, manufacture, construction, and operation of water slide systems. Water slide systems shall be defined as rides intended for use by riders in bathing attire where the action of the ride involves possible and purposeful immersion of the rider's body either in whole or in part in water, and uses circulating water to mobilize or lubricate the rider's transportation along a purpose built path. This includes slides used with or without vehicles as defined below. The terms water slides, waterslides, and slides shall be considered equivalent when used in this practice.

1.2 For the purposes of this practice, a water slide system includes:

1.2.1 The flume,

1.2.2 The water-circulation system,

1.2.3 The starting platform with associated means of access and egress,

1.2.4 The structural supports,

1.2.5 Vehicles or other aquatic accessories that are part of the water slide as defined by the manufacturer, and

1.2.6 Means of slide termination.

1.3 This practice shall not apply to:

1.3.1 Any water slides installed in private residences,

1.3.2 Water flume amusement rides where contact with water is merely incidental (for example, log flume rides, shoot-the-chutes),

1.3.3 Amusement rides and devices whose design criteria are specifically addressed in another ASTM standard,

1.3.4 Lazy river type attractions operating at constant elevation, constructed in the ground, and

1.3.5 Pre-existing designs manufactured after the effective date of publication of this practice if the design is service proven or previously compliant, as defined in Section 3.1.26 of Practice F 2291, and the manufacturer provides:

1.3.5.1 A historical summary of the water slide, or major modification as defined in Terminology F 747, and

1.3.5.2 A statement that the design is service proven or previously compliant. Water slides and major modifications to water slides may qualify as previously compliant for five years following the date of publication of this practice. Thereafter, water slides and major modifications to water slides must qualify as service proven or meet the requirements of this practice.

1.3.5.3 Service proven or previously compliant designs shall comply with Section 7.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are for information only.

NOTE 1—The conversion factor from inch-pound to metric units is 1 in. = 25.4 mm, and 1 lb = 4.4482 N.

1.5 This practice includes an Appendix, which provides additional information to enhance the user's understanding of and application of the criteria presented in this practice, for example, rationale, background, drawings, interpretation, or commentary. The information in the Appendix shall not be considered a mandatory part of this practice.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 570 Test Method for Water Absorption of Plastics

D 638 Test Method for Tensile Properties of Plastics

D 790 Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

F 698 Specification for Physical Information to be Provided for Amusement Rides and Devices

F 747 Terminology Relating to Amusement Rides and Devices

F 770 Practice for Operation Procedures for Amusement Rides and Devices

F 846 Guide for Testing Performance of Amusement Rides and Devices

[1] This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.70 on Water Related Amusement Rides and Devices.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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F 853 Practice for Maintenance Procedures for Amusement Rides and Devices
F 893 Guide for Inspection of Amusement Rides and Devices
F 1193 Practice for Amusement Ride and Device Manufacturer Quality Assurance Program and Manufacturing Requirements
F 1305 Guide for Classification of Amusement Ride and Device Related Injuries and Illnesses
F 2291 Practice for Design of Amusement Rides and Devices
2.2 *ACI Standard:*[3]
ACI-318 Building Code Requirements for Structural Concrete
2.3 *ASCE Standard:*[4]
ANSI/ASCE 7 Minimum Design Loads for Buildings and Other Structures
2.4 *USDA Document:*[5]
USDA-72 The Wood Handbook

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *average slope*—slide height divided by the length of flume, expressed in percent, does not include slide entry components or length of run out section.

3.1.2 *closed flume*—flume that encloses the rider in a pipe-like cross-section.

3.1.3 *fall distance*—vertical distance between the terminus of the slide surface and the water surface of the landing pool.

3.1.4 *flow meter*—device used to measure the water flow for a water slide.

3.1.5 *flume*—that part of the water slide that contains the rider(s) and defines the path of the water slide within which sliding takes place.

3.1.6 *flume riser (splashguard)*—extension of the sidewall of an open flume to contain riders or water and is capable of use as a riding surface.

3.1.7 *instructional signage*—signage displayed in public view prior to the entrance of the ride with information provided to the rider, which informs them of instructions for proper use, riding position, and expected rider behavior.

3.1.8 *landing pool*—pool intended to receive riders from a water slide.

3.1.9 *landing zone*—area in a landing pool intended for receiving riders from a particular slide.

3.1.10 *lifeguard*—individual specially trained in lifesaving and emergency procedures, responsible for monitoring patrons and responding to aquatic and other emergencies.

3.1.11 *mat*—flexible sheet usually made of plastic or foam, suitable for use as a vehicle in a water slide flume to carry a rider.

3.1.12 *multiple dispatch slide*—slide that is designed for the slide attendant to dispatch or allow two or more individual riders or vehicles in the flume at one time.

3.1.13 *open flume*—flume that does not completely encircle or enclose the rider.

3.1.14 *owner/operator*—person or organization that is responsible for the maintenance and operation of a water slide system.

3.1.15 *rider*—any person who is in the act of entering the flume, using the flume, or getting off of the flume.

3.1.16 *rider oscillation*—repeated movement of rider or vehicle, or both, back and forth across the width of a water slide flume.

3.1.17 *run-out section*—flume surface of a water slide where riders are intended to decelerate or come to a stop, or both.

3.1.18 *sign*—display of symbols or language reasonably calculated to communicate information to riders or their parents or guardians, including placards, stickers, pictures, pictograms, guidebooks, brochures, video, and visual signals.

3.1.19 *slide attendant*—individual trained in facility and ride-specific emergency procedures, slide operating procedures, and responsible for dispatching and controlling rider intervals as they enter and exit on water slides and attractions.

3.1.20 *safety sign*—signage displayed in public view, prior to the entrance of the water slide, with information provided to the rider, which includes restrictions, warnings, and instructions.

3.1.21 *single dispatch slide*—slide that is designed for the slide attendant to dispatch or allow only a single rider or vehicle in the flume at one time. The rider or vehicle must clear a specific exit point before the slide attendant dispatches the next rider or vehicle.

3.1.22 *slide entry section*—that part of the water slide where riders enter the flume from the starting platform.

3.1.23 *slide exit section*—that part of the water slide where riders leave the flume to come to a stop in a landing pool.

3.1.24 *slide height*—difference in elevation from the centerline of the flume at the slide exit to the centerline of the flume at slide entry, measured at the riding surface.

3.1.25 *slide length*—total length of the geometric invert of the flume from the slide exit to the slide entry.

3.1.26 *slide path*—geometric layout of the flume sections that make up the water slide.

3.1.27 *slide vehicle*—device intended for use on a water slide upon which the rider(s) sits or lays while sliding.

3.1.28 *specialty vehicle*—proprietary vehicle sufficiently different from other vehicles designated by the slide manufacturer as suitable for use in a water slide.

3.1.29 *starting platform*—deck structure, usually of separate construction from the water slide, from which a given water slide starts.

3.1.30 *warning signage*—signage displayed in public view prior to the entrance of the water slide provided to the rider identifying the features the rider will experience such as lighting effects.

3.1.31 *water flow*—water volume per unit time for a given water slide.

[3] Available from American Concrete Institute (ACI), P.O. Box 9094, Farmington Hills, MI 48333.
[4] Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.
[5] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

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3.1.32 *water slide*—see definition in Section 1.

3.1.33 *water slide clearance envelope*—design clearance to minimize the opportunity for contact between the rider and other objects, outside of the flume, where said contact is likely to cause injury. See Figs. 1 and 2.

3.1.34 *water slide system*—see definition in Section 1.

3.1.35 *water slide tube*—inflated vehicle that floats in a stable fashion in a pool intended for rider use on water slides. The vehicle may have a bottom or have a hole intended for seating and contains one or more riders as they ride in the flume; often called a raft, boat, or tube.

3.2 *Slide Classification*—Water slides are classified by their physical and intended use characteristics. The classification may be a combination of the specific rider vehicle used the type of geometric path, often serpentine or straight, and the designation as a speed slide if the rider's velocity exceeds 25 ft/s. The following are definitions of the types of water slides.

3.2.1 *body slides*—water slide used without a vehicle.

3.2.2 *children's slides*—Water slides generally intended only for use by persons under the height of 48 in. Water slide has a maximum fall distance of 3 in. from slide exit where the rider enters the water and water depth is no greater than 24 in.

3.2.3 *mat slides*—water slide used with a designated mat as a vehicle.

3.2.4 *serpentine slide*—curved path as viewed in geometric slide path.

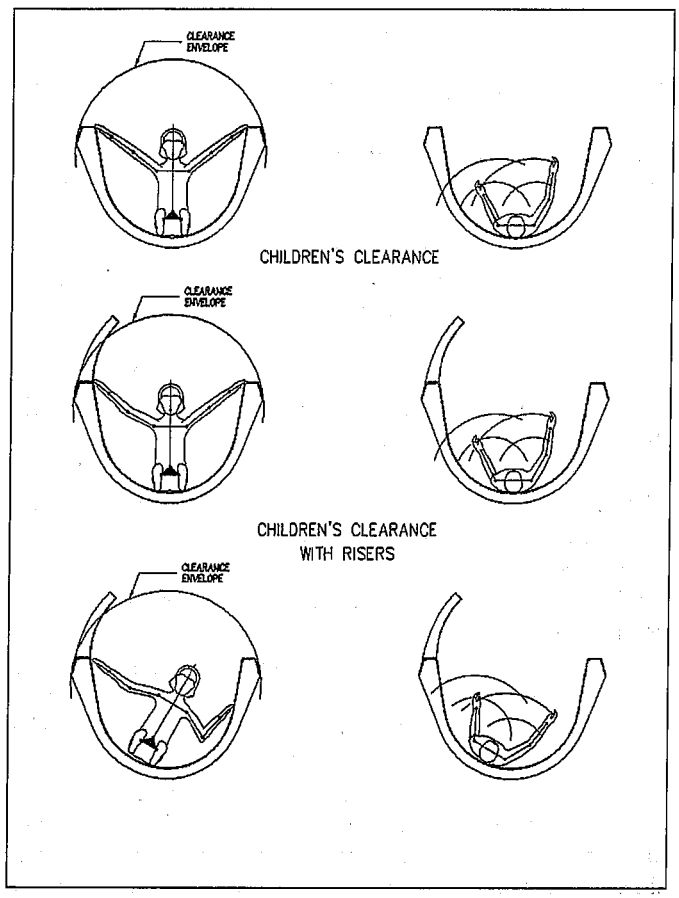

FIG. 1 Water Slide Clearance Envelope

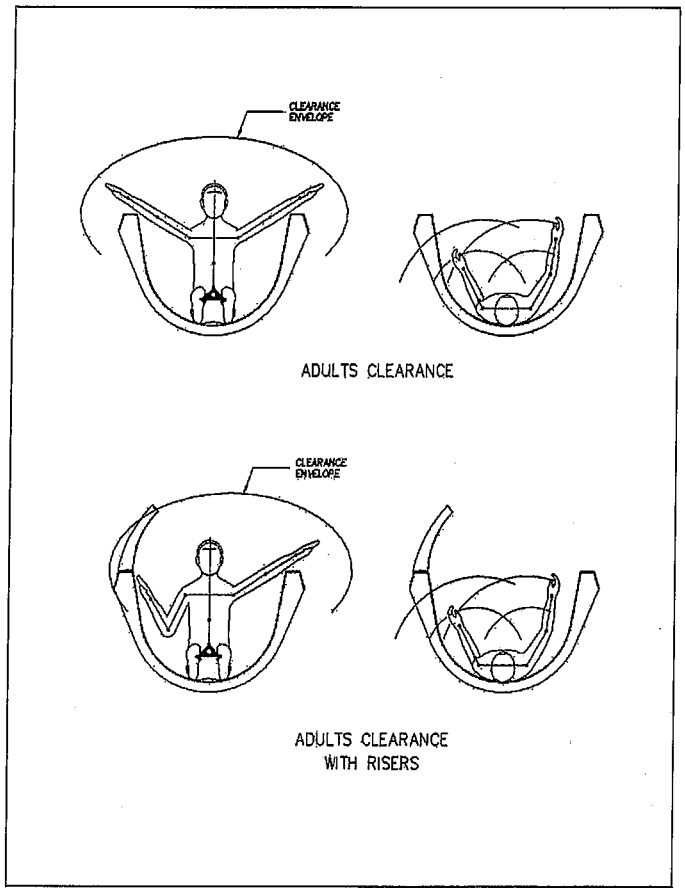

FIG. 2 Water Slide Clearance Envelope

3.2.5 *specialty slides*—proprietary water slide design, such as an uphill, half-pipe, or bowl ride, which does not conform to standard classification.

3.2.6 *specialty vehicle slides*—water slide used with a proprietary vehicle specified by the manufacturer.

3.2.7 *speed slide*—water slide where the rider(s) achieve a velocity of 25 ft/s or more during the course of the ride.

3.2.8 *tube slides*—water slide used with a single or multi-person water slide tube.

4. Materials

4.1 *Flume Material*—Any material that has the following basic properties and that meets all other requirements of this practice may be used to construct water slides.

4.1.1 Flumes riding surfaces shall be constructed to be smooth.

4.1.2 Flume material shall be demonstrated as strong enough to support specified loads as defined in Section 7.

4.1.3 Flume components, maintained using the manufacturer's instructions, shall not deteriorate over time in such a way that a hazard will develop.

4.2 *Support Materials*—Any material that has the following basic properties and that meets all other requirements of this practice may be used to construct water slide supports.

4.2.1 Supports for water slides shall be constructed from durable materials such as wood, metal, concrete, or engineered composites.

4.2.2 Supports for water slides from metal shall be either inherently corrosion resistant, or be finished in such a way as to provide protection from corrosion.

4.2.3 Wood materials shall be finished in such a way to provide protection against deterioration.

4.2.4 Support material shall be demonstrated as strong enough to support specified loads as defined in Section 6.

4.2.5 Supports shall be constructed to accommodate regular inspection and maintenance for structural integrity, material deterioration, or corrosion, or a combination thereof.

5. Notification Requirement

5.1 A water slide system shown to comply with this practice shall meet all applicable requirements specified in this practice. Anyone representing compliance with this practice shall keep such essential records as are necessary to document any claim that the requirements within this specification have been met.

5.2 The owner/operator of a water slide shall notify the appropriate manufacturer(s) of any known incident as specified in Guides F 1305 and F 893.

5.3 The manufacturer shall notify the appropriate owner(s)/operator(s) of similar water slides of an incident that resulted in a serious injury promptly upon the determination by the manufacturer that the incident is significantly repeatable.

5.3.1 Such manufacturer notification shall be a bulletin as specified in Sections 4.1.14.3 through 4.1.14.8 of Practice F 853.

6. Structural Design of Water Slides

6.1 This section defines the loading and strength criteria that shall be used in the structural engineering of water slide flumes and supporting structures. The strength and stability of the water slide system shall be demonstrated by generally accepted engineering methods certified by a professional engineer.

6.2 *Dead Loads (symbol DL)*—Forces resulting from weight of all components of the ride and includes all loads that do not fluctuate with respect to time.

6.3 *Operational Loads*—Forces from water, riders, or vehicles, or a combination thereof, in the ride under normal operations.

6.3.1 *Water Load (symbol WL)*—In free flowing water slides where water does not collect in pools or streams greater than 2 in. deep, the water load shall be a minimum of 15 lbs/linear ft for every 1000 gal/min of flow. Where the flow is such that water collects in pools or streams greater than 2 in. deep, the actual maximum water load shall be determined and used in calculation, design, or load tests, or a combination thereof.

6.3.2 *Rider Load (symbol RL)*—The manufacturer shall specify the rider vehicle and the maximum number of riders that are to ride in the flume at one time.

6.3.2.1 For water slides intended for multiple rider use, the weight assigned to each rider shall be, at a minimum, the weight specified for an adult rider in Section 8.6.1 of Practice F 2291.

6.3.2.2 For single rider water slides, the rider weight shall be a maximum of 300 lb.

6.3.2.3 For water slides intended for use by children only, the weight assigned to a child shall be as specified in Section 8.6.2 of Practice F 2291.

6.3.2.4 Ride loads shall be so arranged to cause the greatest realistic operational load to the system.

6.3.2.5 Lateral centripetal forces shall be considered in curved sections of flume. Predicted rider speeds should be used to calculate these forces. If speeds cannot be predicted, then a minimum of 15 ft/s for flumes under 15 % slope and 30 ft/s for all other flumes shall be used.

6.3.2.6 If the manufacturer places maximum rider total weight limits on a slide, then that restricted load may be used.

6.3.2.7 The weight of the rider vehicle shall be included in determining rider load.

6.4 *Environmental Loads*—Forces from environmental conditions of the site such as wind, precipitation, earthquake, and changes in temperature.

6.4.1 Loads and forces due to environmental conditions shall be in accordance with applicable local code requirements or ANSI/ASCE 7, or other equivalent national standard.

6.4.2 The manufacturer/designer shall clearly indicate the environmental loads the water slide was designed for in the operating and maintenance instructions as specified in the sections on Manufacturer's Responsibility of Practices F 770 and F 853. In addition to the environmental load information, any restriction, limitations, or special procedures associated with water slides exposed to these environmental loads shall be included.

6.4.3 *Lateral Wind Load (symbol LWL)*—For outdoor slides, the minimum wind load for all types of water slides shall be calculated based on 100-mph wind (3-s gust) for non-operational conditions. Lateral wind load may be reduced by an importance factor of less than 1.0, where appropriate, for water slide structures that are unoccupied during extreme weather.

6.4.4 *Reduced Lateral Wind Load (symbol RLWL)*—For outdoor slides, the minimum wind load for all types of water slides shall be calculated based on Section 8.13.1 of Practice F 2291 for operational conditions.

6.4.5 *Other Lateral Loads (symbol OLL)*—A minimum lateral load equivalent to 10 % of the dead weight of the structure shall be included.

6.4.6 *Snow Load (symbol SL)*—The snow load for all types of water slides shall be calculated in accordance with the relevant local ground snow load(s).

6.5 *Overload*—Forces from water, riders, or vehicles, or a combination thereof, under extraordinary operational conditions due to user overload.

6.5.1 Calculations for extraordinary operational conditions that consider user overload shall be based on conditions specified by the manufacturer and need not consider any other live load in combination with such overload.

6.6 *Load Combinations*—Engineering calculations may use either allowable stress methods (ASD) or load and resistance factor methods (LRFD). Engineering calculations shall consider load conditions and combinations of loads in accordance with generally accepted engineering methods. Calculations

shall consider that water slide systems may not be occupied during extremes of weather.

6.7 *Metal Structures*—Strength of steel structures under or above noted loads shall be designed in accordance with current AISC, ASCE standards,[4] or equivalent national standards.

6.8 *Wood Structures*—Strength of timber structures under or above noted loads shall be designed in accordance with current USDA-72, ASCE standards,[4] or equivalent national standards.

6.9 *Concrete Structures*—Strength of concrete structures under above noted loads shall be designed in accordance with current ACI-318 or equivalent national standards.

6.10 *Plastic and Plastic Composite Structures*:

6.10.1 Strength of plastic structures under above noted loads shall be designed in accordance with generally accepted engineering methods. Assessment shall be performed in a manner suitable for the specific material and structure.

6.10.2 Fiberglass reinforced plastic or other composite materials used structurally shall have samples tested for strength with accelerated aging in accordance with Test Methods D 570, D 638, and D 790.

6.10.3 Loads from normal operational conditions shall demonstrate a minimum of 5 to 1 factor of safety against rupture for fiberglass reinforced plastic or other composite materials.

6.10.4 Calculations for extraordinary operational conditions from user overload shall demonstrate a minimum of 2 to 1 factor of safety against rupture of fiberglass reinforced plastic or other composite materials.

7. Performance Requirements

7.1 *General Requirements*:

7.1.1 The following are minimum requirements and should not be substituted where manufacturer experience suggests more acrimonious values.

7.1.2 Surfaces in reach by slide attendants and riders shall be made in such a way as to reduce the potential for injury.

7.1.3 A water slide shall be designed and constructed so that forces on riders allow the rider to use the slide in accordance with the rules and instructions under normal operating conditions.

7.2 *Slide Access*:

7.2.1 *General*—Fencing, guardrails, and handrails shall be installed in accordance with Section 14 of Practice F 2291.

7.2.2 If the water slide system includes a starting platform and the platform is more than 21 in. above surrounding terrain, the platform shall provide at least 36 in. in distance between the slide entry and the top of stairs or ramp. Sufficient space shall be provided on the platform for slide attendant workspace, signage, and any communication devices needed for operation. Except where a stair or ramp or slide entry joins it, the platform shall be surrounded on all sides by a guardrail in accordance with Section 14 of Practice F 2291.

7.2.3 Surface of steps, access ramp, and deck shall be slip-resistant and self-draining.

7.2.4 Slide entry section should interface with the platform guardrail so that a 4 in. sphere cannot pass between the slide entry component and the adjacent guardrail component.

7.3 *Open Flume Geometry*:

7.3.1 Flume cross-section shape shall be configured to contain the rider(s) or vehicle, or both, under all reasonable operating conditions. Total depth of section and shape of cross-section of a flume may be created in a single piece or more than one piece.

7.3.2 Open water slide flumes shall be kept clear of obstacles within the water slide clearance envelope as shown in Figs. 1 and 2. Flume riser sections may be added to block access to anything encroaching in the area.

7.3.3 Water slides shall have additional sidewall height provided by a flume riser section on the outside part of all horizontal curves to contain the rider. This flume riser shall be concave facing the center of the cross-section. The flume riser may be an integral or separate part from the main flume component.

7.3.3.1 *Flume Riser Transition*—Flume riser parts shall be transitioned from sections without flume risers to sections with flume risers with a maximum angle of 45° from the horizontal. See Fig. 3.

7.3.3.2 *Other Additions*—Where a cover, a tube entrance, or a flume riser is fitted other than at the beginning of the slide, the sides of the slide shall have a smooth transition from horizontal to vertical. Maximum angle of transition will be 45°. The inside height of the entrance to the cover or flume riser shall be at least 48 in.

7.3.4 Body slides with curved bottom flume sections such that the cross-section of the bottom and the sides are a continuously curving surface shall have:

7.3.4.1 Minimum inside width of 30 in., minimum sidewall height of 15 in., and

7.3.4.2 The top 1 in. of curved sidewalls shall be within 10° of vertical.

7.3.5 Tube slides with flat bottom flume sections shall have:

7.3.5.1 Minimum width of 48 in. inside sidewalls,

7.3.5.2 Minimum sidewall height of 24 in, and

7.3.5.3 Sidewalls that are straight may diverge from vertical a maximum of 2 in. measured at 24 in. from bottom.

7.3.6 Tube slides with curved bottom flume sections such that the cross-section of the bottom and the sides are a continuously curving surface shall have:

7.3.6.1 Minimum inside width of 52 in.,

7.3.6.2 Minimum sidewall height of 26 in., and

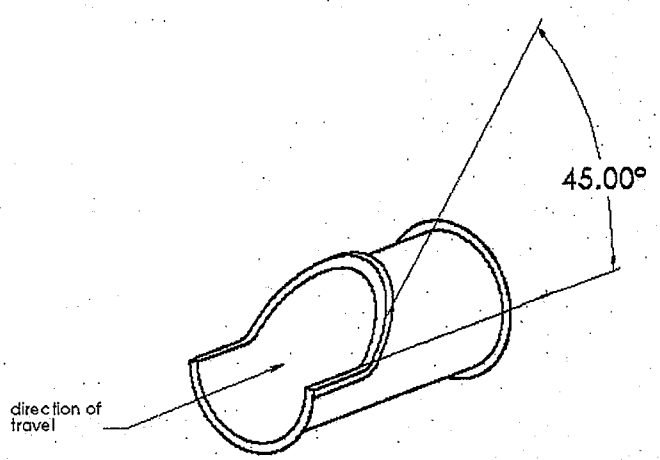

FIG. 3 Flume Riser

7.3.6.3 The top 1 in. of curved sidewalls shall be within 10° of vertical.

7.3.7 Mat slides that are straight in plan shall have:

7.3.7.1 Minimum width of 22 in. inside sidewalls,

7.3.7.2 Minimum sidewall height of 16 in.,

7.3.7.3 Sidewalls that are straight may diverge from vertical a maximum of 6 in. measured at 16 in. from bottom, and

7.3.7.4 The top 1 in. of curved sidewalls shall be within 10° of vertical.

7.3.8 *Multiple Parallel Lane Flumes*—Where more than one flume runs in parallel straight-line path (in plan).

7.3.8.1 The outermost sections shall have sidewalls a minimum of 24 in. in height.

7.3.8.2 Where the flume path runs adjacent, there shall be a dividing barrier a minimum of 8 in. high between the lanes.

7.3.8.3 Each lane shall be a minimum of 22 in. inside width.

7.3.9 Water slides such as specialty slides that cannot be classified above shall conform to the requirements of 8.4.

7.3.10 Combination rides may be designed such that sections of the slide conform to the requirements of the respective specifications above.

7.4 *Closed Flume Geometry*:

7.4.1 The following are minimum requirements and should not be substituted where manufacturer experience suggests more conservative values. Total shape of cross-section of a flume may be created in two or more pieces.

7.4.2 Body slides with curved bottom flumes shall have a minimum inside dimension of 30 in.

7.4.3 Tube slides with flat bottom closed flume sections shall have a minimum inside dimension of 48 in.

7.4.4 Tube slides with curved bottom closed flume sections shall have a minimum inside dimension of 52 in.

7.5 *Flow Rate*—The water flow in each slide has an effect on the performance of the sliding surface.

7.5.1 The manufacturer shall determine the flow rate and shall set a fixed range of acceptability for each installation at the time of commissioning.

7.5.2 The water flow valves shall be secured from interference or adjustment by unauthorized personnel.

7.5.3 Flow meters, calibrated means of flow measurement, or marker indicating proper operational water flow/level shall be provided to for each flume.

7.6 *Run Out Lanes*:

7.6.1 Run out sections shall be designed to contain, decelerate, and stop riders to allow them to exit the slide.

7.6.2 A weir or other device shall regulate the water level in the run out to the correct level given correct flow rate for the ride.

7.6.3 To facilitate proper deceleration, a marker shall be provided to indicate the operational water level in the run out, which the slide attendant/lifeguard may verify prior to allowing the next rider entry to the slide.

7.7 *Landing Pools*:

7.7.1 Landing pools shall be designed to decelerate and stop riders and allow them to exit the water slide without encountering an obstruction.

7.7.2 The exit path for riders shall not cross with the landing zone of other slides. The designated pool exit shall be such as to force the riders to move forward and away from the paths of riders from other flumes.

7.7.3 Water slides entering a landing pool shall have a landing pool of sufficient length to decelerate and stop riders and minimize the potential for contact with the pool wall or stationary objects (stair, ladder, railing, and so forth) in the landing pool. Water slides classified as speed slides (rider velocity over 25 ft/s) will require additional pool length.

7.7.4 Pool depth in the landing zone for water slides for persons over 48 in. tall shall have a minimum pool depth of 3 ft.

7.7.5 Flume geometry at pool entry shall be straight viewed in plan for the last 8 ft of the water slide entering a pool.

7.7.6 Landing pools for waterslides with a fall distance greater than 6 in. shall have an increase in pool depth from the 3 ft minimum according to manufacturer recommendation to minimize potential impact with pool bottom.

7.7.7 If water supply for the slide(s) is drawn directly from landing pools or other areas accessible to the public, the suction line shall be divided into at least two lines, where connected to the pool, such that one person cannot block more than one suction line. The fittings and piping details shall be designed so that the full volume of water for the slide may be drawn through the remaining fittings at a velocity not to exceed 1 ft/s, assuming one suction fitting is fully blocked.

7.7.8 *Body Slide Landing Pools*:

7.7.8.1 Body slides entering a landing pool shall have a minimum distance between the inside of the widest part of the flume riding surface and the closest pool wall of 5 ft. The place of measurement in the pool shall be at any point from water level to 3 ft below water level and 6 ft in front of the flume termination. The lateral pool wall shall be parallel to or diverge from the axis of the slide. See Fig. 4.

7.7.8.2 Body slides entering a common landing pool should be arranged so riders do not come in contact with each other when exiting the flumes of adjacent slides simultaneously.

7.7.9 *Tube Slide Landing Pools*:

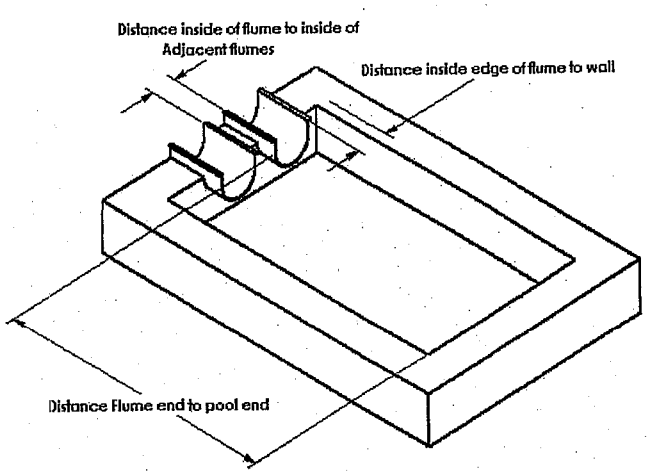
Distance inside of flume to inside of Adjacent flumes
Distance inside edge of flume to wall
Distance Flume end to pool end

FIG. 4 Body Slide Landing Pool

7.7.9.1 Tube slides entering a landing pool shall have a minimum distance between the inside of the widest part of the flume riding surface and the closest pool wall of 4.5 ft. The place of measurement in the pool shall be at any point from water level to 3 ft below water level and 6 ft in front of the flume termination. The pool wall shall be parallel to or diverge from the axis of the slide. See Fig. 4.

7.7.9.2 Tube slides entering a common landing pool should be arranged to minimize the opportunity for contact with other riders when exiting the flumes of adjacent slides simultaneously.

7.8 *Openings and Apertures in Flume Surfaces*:

7.8.1 Openings may be provided in flume surfaces for introduction of water, drains, special effects, light, and other similar purposes. All edges in openings within reach of riders shall be smooth with a minimum radius of ⅛ in. Openings shall not present an entrapment risk.

7.8.2 Openings at the slide start for the main water supply do not require guards or gratings unless the rider stands, sits, walks, or slides over the face of the opening during normal slide operation, or if the configuration of the opening is such that a rider moving in the usual direction of travel would not become entrapped. Grating shall have a maximum width of slot or hole diameter of ½ in.

7.9 *Seams and Joints*:

7.9.1 The surface of the sliding section shall form a smooth, secure, and continuous surface. If adjacent edges of lateral joints are not perfectly tangent, the upstream edge shall be set above the downstream edge on the riding surface a maximum of 3⁄16 in. to ensure that riders will not hit the edge of a lateral joint. (For the purposes of this section, riding surface shall be taken to mean the part of the flume where the path of riders is expected or found to pass over, for example, the outside half of a curved flume section.)

7.9.2 Longitudinal joints on the riding surface shall be made tangent.

7.9.3 Edges of lateral joints on body slides may have a radius of up to 3⁄16 in. Edges of longitudinal joints in closed flumes may have a radius of up to ¼ in. Edges of longitudinal joints in open flume risers may have a radius of up to ⅜ in.

7.9.4 Edges of lateral joints on mat and tube slides may have a radius of up to ½ in.

7.10 *Accelerations*:

7.10.1 Slide paths shall be designed so riders in seated or prone (laying face down) positions do not experience greater than 2 Gs acceleration from gravity and centrifugal acceleration vectors added together. This limit may be increased to 3 Gs if the duration is less than 1 s.

7.10.2 Slide paths shall be designed so that riders in supine (laying face up) positions do not experience greater than 3 Gs acceleration from gravity and centripetal acceleration vectors added together.

7.11 *Slide Vehicles*:

7.11.1 Slide vehicle(s), if specifically required by the manufacturer, shall be utilized.

7.11.2 Alternative slide vehicles shall be approved for use on water slides in writing from the manufacturer prior to guest use.

7.11.3 In the event the manufacturer does not provide written documentation of approval for an alternative slide vehicle, testing shall be performed and documented to determine if the proposed alternative vehicle is acceptable as outlined in Section 8.

7.11.4 Slide vehicles shall be maintained in operating condition, including but not limited to all handles or other holding devices, and conditions of vehicle surfaces in contact with the slide surface.

7.11.5 Slide vehicles should be removed from service for repair or replacement when components are missing or damage is detected, or both.

7.11.6 Slide vehicles shall be constructed to have a cushioning effect for riders who can come into contact with another vehicle during normal operation of the slide.

7.11.7 Slide vehicles shall float when used in a landing pool.

8. Test and Inspection Methods

8.1 The manufacturer of a new slide or major modification to an existing slide shall specify prior to commissioning or re-certification, test or inspection procedures, or both, in compliance with Guide F 846 and Practice F 1193, including but not limited to the following.

8.2 *Operational Testing*—As specified in Guide F 846, Section 7.

8.3 The manufacturer shall provide a written report to the owner/operator, which provides detail of the installation and operational test procedures, time and place of test, test results and supporting data, and identification of the person conducting the test.

8.4 *Special Testing*—In the event that a new or innovative product or method is used in the design, construction, or operation of a water slide that does not comply with Section 7, such a product shall be deemed acceptable as follows.

8.4.1 The manufacturer shall prepare a testing procedure, this procedure shall be designed to verify the performance of the slide that does not otherwise comply with Section 7 of this practice.

8.4.2 The test procedure shall include riders that represent the largest and the smallest body types that shall be allowed on the slide.

8.4.3 The test procedure shall be reviewed and approved by a third party consultant experienced and an expert in water slide operations.

9. Identification Marking

9.1 Installed water slides shall be identified in accordance with Specification F 698.

10. Manufacturer Responsibilities

10.1 The following instructions outline requirements under Practice F 770 as applicable to water slides and include requirements not specified in Practice F 770 which are necessary and unique to water slides. Manufacturers are responsible for determining the following:

10.2 Water flow rate requirements for water slide operation and point at which water level in run outs or landing pools are benchmarked.

10.3 Maximum total passenger weight and maximum number of passengers per slide vehicle.

10.4 Recommended patron dispatch intervals.

10.5 Recommended warnings concerning forces and actions that could aggravate physical conditions such as heart conditions, pregnancy, neck and back conditions, and so forth.

10.6 Specifications for inspection, maintenance and repair of the slide that shall include, but not be limited to, the following:

10.6.1 A phone number or fax number to be used by the owner/operator to secure maintenance or operating assistance from the manufacturer.

10.6.2 Periodic minimum service and component inspection checklists.

10.6.3 Cleaning, waxing, repairing, and patching instructions to include recommended materials.

10.6.4 Description of the recommended, daily pre-opening inspection to be performed by slide attendants or maintenance personnel, or both, prior to daily operations should include but not be limited to:

10.6.4.1 Obstruction in the slide path,

10.6.4.2 Cracks, chips, or bubbles in the sliding surface,

10.6.4.3 Rough patch work at joints or cracks,

10.6.4.4 Leaking seals or joints,

10.6.4.5 Loose flume risers in turns,

10.6.4.6 Excessive movement of the flume,

10.6.4.7 Joint openings,

10.6.4.8 Signage placement,

10.6.4.9 Communication device functional,

10.6.4.10 Water flow rate in operating range,

10.6.4.11 Landing pool or run out water level in operating range,

10.6.4.12 Visual check of slide vehicles, and

10.6.4.13 Visual inspection of entrances, exits, stairways, and ramps.

11. Owner/Operator Responsibilities

11.1 As specified in Section 4 of Practice F 770, the following instructions outline requirements as applicable to water slides and include requirements not specified in Practice F 770 which are necessary and unique to water slides.

11.2 Each owner/operator shall have written operating procedures for the individual water slide, which are an integral part of their staff-training program. These procedures shall include but not be limited to:

11.2.1 Specific water slide operation policies and procedures with pertinent information from the manufacturer's instructions including dispatch procedures. Dispatch procedures shall be established for each water slide should include, but not be limited to, the following:

11.2.1.1 Informing each patron of the proper rider position.

11.2.1.2 Established dispatch time intervals for each water slide.

11.2.1.3 Established communication system between the slide attendant and lifeguard positioned at the landing pool or run-out section.

11.2.1.4 Limiting the number of patrons in the dispatch pool to the number of intended riders.

11.2.1.5 Established dispatch procedures shall be followed by slide attendants prior to dispatching each rider.

11.3 Verbal instructions, concerning water slide rules that shall be announced to patrons prior to each ride cycle. Pre-ride instructions may include, but not be limited to: the required position of hands and feet, rider conduct, exiting procedures, and other instructions deemed appropriate.

11.4 Signage shall be placed by the owner/operator as specified in Practice F 770. For water slides, these signs shall include safety, warning, and instructional signage reflecting manufacturer recommendations. Signage shall be prominently displayed at the slide entrance or other appropriate area, or both, and shall include but not be limited to the following:

11.4.1 Instructions, which include:

11.4.1.1 Proper riding position,

11.4.1.2 Expected rider conduct,

11.4.1.3 Dispatch procedures,

11.4.1.4 Exiting procedures, and

11.4.1.5 Obey slide attendant/lifeguard instructions.

11.4.2 Warnings, which include:

11.4.2.1 Slide characteristics, such as descriptions of speed or attraction rating, and

11.4.2.2 Water depth of landing zone.

11.4.3 Requirements which include:

11.4.3.1 Riders being free of medical conditions, including but not limited to pregnancy and heart, back, or musculoskeletal problems,

11.4.3.2 Maximum/minimum height and weight, and

11.4.3.3 Any swimming or physical ability requirement, or both.

11.5 *Major Modifications*—As specified in Terminology F 747, major modifications shall not occur without written approval from the manufacturer.

11.5.1 In the event the manufacturer does not provide written approval for a major modification, the owner/operator may retain a different manufacturer or designer/engineer to complete or approve the major modification, or both.

11.5.2 Testing shall be performed and documented in accordance with Guide F 846 to verify the modification is acceptable as outlined in Section 8 of this practice.

11.6 The owner/operator shall maintain appropriate water quality in accordance with local requirements for bathing facilities.

11.7 *Inspection and Maintenance Program*—Based on the water slide manufacturer's recommendations, each owner shall implement a program of maintenance, testing, and inspection, providing for the duties and responsibilities necessary to care for the water slide, safety equipment, and the slide facilities.

11.7.1 Inspections shall be conducted in accordance with the procedures as specified in Practices F 770 and F 853.

11.8 Visual checks of safety signs, slide entry, flume, run out, landing pool, and structural components, water flow, landing pool water level, and run out water level shall be maintained according to the manufacturer's specifications.

12. Rider Responsibility

12.1 See Practice F 770.

13. Keywords

13.1 construction; design; flume; manufacture; water slide

APPENDIX

(Nonmandatory Information)

X1. COMMENTS

X1.1 Section 3.1, Terminology

X1.1.1 Many terms have a common accepted use in the water slide industry that is unique. This is to establish a basic common vocabulary as well as a basis for classification that differentiates design parameters. All terms in this practice are candidates for inclusion in Terminology F 747.

X1.2 Section 3.1.33, Clearance Envelope

X1.2.1 Water slides are distinct from other amusement rides in that riders are not restrained and may assume unusual and arbitrary positions. Hence the methodology of assuming a statistical dimension of a body part restrained in a vehicular harness is not applicable to slide designs. Historically, manufacturers have set individual internal standards. The desire in this practice is to establish generally agreed upon values that have provided historically safe rides.

X1.3 Section 4.2, Support Materials

X1.3.1 Many materials have been used for water slide supports including: steel, concrete, wood, aluminum, and fiberglass reinforced plastics. Corrosion has proved the major issue for metal construction primarily for cosmetic concerns. With respect to corrosion of metals, maintenance has proved the most effective factor in minimizing occurrence. Requirements are left deliberately open and emphasize the performance issue of durability and strength.

X1.4 Section 6, Structural Design of Waterslides

X1.4.1 Fundamentally, water slides and related access structures should not be considered the same as buildings. Some loading conditions commonly accepted for buildings simply will not occur for water slides. Therefore, complete adherence to building codes requires unreasonable load combinations. The simplest example is loads from high winds. No water slide is operated during a storm. Water slides are not intended to provide the function of shelter. Section 8.13 of Practice F 2291 recognizes this for amusement rides where operational loads are calculated with 34 mph wind.

X1.4.2 Some manufacturers depend on designs prepared for an example job for all jobs. Some use load-testing criteria. In Europe, TUV will perform tests on water slides using proof loads if calculations are not submitted.

X1.4.3 The intent here is to establish a commonly acceptable base standard for designs. If individual jurisdictions decide to require application of local building codes that is their right.

X1.4.4 Combinations of loads for design analysis or for determining test forces:

DL + WL + RL
DL + SL + LWL
DL + LWL
DL + RL + (RLWL)
DL + RL + OLL

X1.5 Section 8, Test and Inspection Methods

X1.5.1 Water slides are distinct from amusement rides in that they are mechanically very simple. The only moving component of a slide is the rider. Pumps and mechanical devices are separate and isolated from the rider. One could argue slides have no moving parts. Therefore, requirements for testing and inspection do not require the level of care common with machines. NDT testing of bearings, shafts, and moving parts is unnecessary. The requirements of Guide F 846 are not applicable for the most part. Inspection/testing commonly occurs at three points in water slide manufacture: (*1*) material supply QA, (*2*) manufacture/fabrication QA, (*3*) installation, and (*4*) operation. The last has two aspects, one being verification of the structure often by engineers, and the other being the actual performance of the slide. The following has been modified from the basic Guide F 846 requirements to reflect common practice.

X1.6 Section 8.4, Special Testing

X1.6.1 This section has been added to address concerns that many of the provisions of the performance section would inhibit or prevent innovation. A radical or new ride may introduce a safe feature that goes against requirements in this practice that are based on past experience. Demonstrating this with testing is an obvious solution. However, a higher degree of care and completeness in such testing is required compared to products that have dozens or hundreds of previous successful examples. The use of respected third party consultants is a normal part of water slide operations and management. Therefore, this provides a high level of confidence to verification tests of this type of slide.

X1.7 Section 12, Rider

X1.7.1 Responsibility is based on Section 5.x of Practice F 770, as already accepted by F24.

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